Defense Technical Information Center
Compilation Part Notice

ADP012823

TITLE: IR Luminescence [1.6-1.9 mu m] of Compressive-Strained InGaAs/InP Quantum Wells Grown by MOVPE

DISTRIBUTION: Approved for public release, distribution unlimited
Availability: Hard copy only.

This paper is part of the following report:

TITLE: Nanostructures: Physics and Technology International Symposium [6th] held in St. Petersburg, Russia on June 22-26, 1998 Proceedings

To order the complete compilation report, use: ADA406591

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, etc. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP012712 thru ADP012852

Ioffe Institute
6th Int. Symp. "Nanostructures: Physics and Technology"
St Petersburg, Russia, June 22–26, 1998.

IR luminescence (1.6–1.9 μm) of compressive-strained InGaAs/InP quantum wells grown by MOVPE

Z. N. Sokolova, O. V. Kovalenkov, D. A. Vinokurov,
V. A. Kapitonov and I. S. Tarasov
Ioffe Physico-Technical Institute, St. Petersburg 194021, Russia
E-mail: zina@quant.ioffe.rssi.ru

Abstract. We report metal-organic chemical-vapor deposition-grown $In_xGa_{1-x}As/In_{0.53}Ga_{0.47}As$/InP double heterostructures emitting at 1.65–1.85 μm at room temperature. The active region consists of a 25–100 Å thick compressivelly strained $In_xGa_{1-x}As$ quantum wells with composition x in interval 0.69–0.81. Comparison with our theoretical results shows that the shape of our quantum wells grown by metal-organic vapour phase epitaxy is not rectangular.

Introduction

Semiconductor lasers emitting in the midwavelenght infrared (MWIR) band (1.5–5 μm) have potential applications in high-resolution molecular spectroscopy, optical fiber communication, laser radar, and gas analysis with high sensitivity and speed. Particular attention was given to III–V semiconductor MWIR lasers with Sb contents [1, 2]. Contrary to receive the emission wavelength up to 2.0 μm we use InGaAs/InP heterostructures with strained active region. To the best of our knowledge, so far the detailed study of strained InGaAs quantum wells (QWs) has not provided. Usually strained InGaAsP heterostructures emitted up to 1.5 μm have been investigated [3, 4].

1 Growth

In this work we report double heterostructures $In_xGa_{1-x}As$/InP ($x = 0.69-0.81$) emitted at 1.65–1.85 μm grown by metal-organic vapour phase epitaxy (MOVPE). The low pressure (100 mBar) (LP MOVPE) equipment with rectangular cross-section horizontal reactor and radio-frequency heating of graphite susceptor was used. The trimethylgallium (TMGa), trimethylindium (TMIn), arsine (AsH_3) and phosphine (PH_3) were used as sources. Growth temperature was 600°C.

The heterostructures consist of a 25–100 Å thick undoped compressivelly strained (lattice mismatch 1–2%) active region of $In_xGa_{1-x}As$ ($x = 0.69-0.81$) sandwiched by 0.2 μm thick unstrained $In_{0.53}Ga_{0.47}As$ confinement layers, lattice matched with InP substrate.

2 Results and discussion

Photoluminescence (PL) study of grown heterostructures has been performed at room temperature. Ar^+ laser with 488 nm line has been used for excitation with density of 50 W/cm^2.

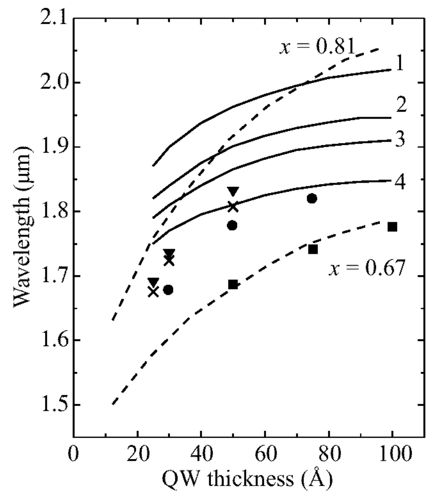

Fig 1. PL data of $In_xGa_{1-x}As$ QWs vs well thickness for different composition (x) at 300 K.

Figure 1 demonstrates the emission wavelength of $In_xGa_{1-x}As/In_{0.53}Ga_{0.47}As$ QWs as function of QW thickness at room temperature. Dots are our experimental data for QWs with different indium content in the well: (triangle): $x = 0.81$, (cross): $x = 0.76$, (circle): $x = 0.73$, (square): $x = 0.69$. The dotted curves are the experimental results for composition $x = 0.81$ and $x = 0.67$ from [5]. The solid curves (1–4) are our theoretical data for the same composition x: 1—0.81; 2—0.76; 3—0.73; and 4—0.69. The calculation has been made for the electron transitions to the first heavy hole level, because determined by strain energy gap between the heavy hole and light hole subbands in $In_xGa_{1-x}As$ compressivelly strained QWs fits into the interval: 64 meV ($x = 0.69$) — 115 meV ($x = 0.81$). Calculations have shown that the QWs in conduction band are very shallow in investigated heterostructures with $In_{0.53}Ga_{0.47}As$ confirement layers. Therefore the wavelength dependence of QW's thickness connected with heavy hole quantization only and the slope of the curves is not sharp in Fig. 1.

It follows from Fig. 1 that the shape of our calculated and measured curves are indentical, but theoretical results shift into the long-wavelength range. The discrepancy between theory and experiment in our opinion is attributable to the fact that the QWs interfaces are not ideal, what can be explained by In segregation from interfaces. As a result, the shape and so the width of the QWs has changed. On the other hand, the segregation can variate the average composition of the solid solution in QWs, especially for narrow wells.

Figure 2 shows our measured dependence of wavelength versus composition x in $In_xGa_{1-x}As$ QWs at 300 K. As shown from figures, the wavelength of 2 μm can be obtained in strongly compressively strained (lattice mismatch 2%) QWs with width up to 100 Å.

3 Conclusion

We have presented $In_xGa_{1-x}As/In_{0.53}Ga_{0.47}As/InP$ heterostructures with compressive-strained QWs grown by LP MOVPE. Preliminary studies of these samples demonstrate

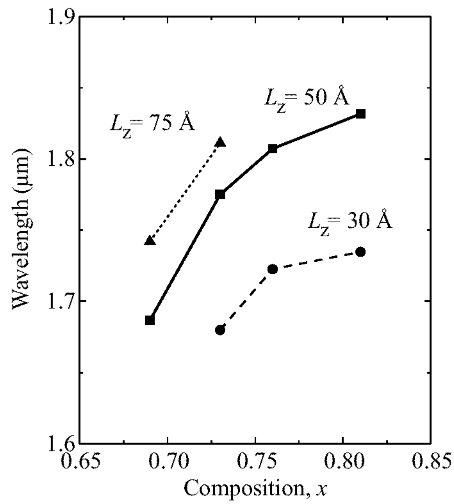

Fig 2. PL data of $In_xGa_{1-x}As$ QWs vs composition (x) for different well thickness at 300 K.

the emission wavelength in a range 1.65–1.85 μm. Comparison of our theoretical and experimental data shows that the shape of grown QWs is not rectangular because of indium segregation from QW's interfaces.

This work was supported by the Russian Foundation for Basic Research, grant No. 98-02-18266 and the program "Physics of solid state nanostructures", grant No. 96-2005.

References

[1] J. Diaz, H. Yi, A. Rybaltowski, et al., *Appl. Phys. Lett* **70** 40 (1997).
[2] D. Z. Garbuzov, R. U. Martinelly, H. Lee, et al., *Appl. Phys. Lett* **69** 2006 (1996).
[3] P. J. A. Thijs, L. F. Tiemejer, J. J. M. Binsma, et al., *IEEE J. Quant. Electron* **QE-30** 477 (1994).
[4] D. Z. Garbuzov, L. Xu, S. R. Forrest, et al., *Electron. Lett* **32** 1717 (1996).
[5] J. Dong, A. Ubukata, K. Matsumoto, *Jpn. J. Appl. Phys.* **36** 5468 (1997).